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BIOLOGY AND MANAGEMENT OF RACCOONS

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Raccoon

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BIOLOGY AND MANAGEMENT OF RACCOONS

DESCRIPTION

The raccoon is a member of the family Procyonidae, which includes five genera: Procyon (raccoon), Bassariscus (ringtails in North and Central America), Nasua (coatis in North, Central, and South American), Potos (kinkajou in Central and South America), and Bassaricyon (olingo in Central and South America. Some place Ailurus (pandas in Asia) in the family Procyonidae, but Honacki et al. (1982:252) state, "Immunological evidence suggests that Ailurus is more closely related to ursids than to procyonids...." Among the order Carnivora the family Procyonidae seems to be most closely related to the family Canidae (coyote, wolves, foxes, and dogs). Kaufmann (1982:567) states, "The earliest known procyonid fossils are from the Oligocene; Procyon has been traced back to the Pliocene, and P. lotor [the raccoon] to the Pleistocene...."

Sanderson (1983:485) reports, "Both Goldman (1950, p. 24) and Hall and Kelson (1959, p. 885) list seven species and twenty-five subspecies, all in the P. lotor group, in the subgenus Procyon and one (crab-eating raccoon) in the subgenus Euprocyon. However, Koopman, Hecht, and Ledecky-Janeck (1957) and McKinley (1959) indicate that the Bahama raccoon (P. maynardi) found on New Providence Island probably resulted from introductions of the mainland form (P. lotor). Koopman, Hecht and Ledecky-Janeck (1957, p. 164) consider the Bahama raccoon as P. l. maynardi. One wonders if further study may change the status from species to subspecies of the other named island species in the subgenus Procyon recognized by Goldman (1950) and Hall and Kelson (1959)." In any case, Procyon is the only genus of the family Procyonidae present in Canada, and P. lotor is the only species of the genus found in Canada.

The black mask and long ringed tail are diagnostic for the raccoon in Ontario. There are five elongate toes on each foot, and the raccoon is flat footed. The dental formula is 3/3, 1/1, 4/4, 2/2, and the carnassial

teeth (Pm^4, M_1) are crushing instead of shearing. Typically there are six mammae, but eight have been observed (Sanderson 1983).

In my experience, average body weights of raccoons in Missouri, Illinois, and Iowa increase about 1.0 lb for each 100-150 miles as you move from north to south. Thus, I would expect raccoons from southern Ontario to weigh more than raccoons from west-central Illinois where I have collected most of my data in recent years. The 29-year averages for my data from west-central Illinois (1955-56 through 1983-84) are as follows: juvenile males, 5,153 g, juvenile females, 4,808 g, adult males, 7,557 g, and parous females, 6,432 g (Sanderson 1984). By comparison, I have calculated the average weights, presumably of carcasses, reported for raccoons taken by hunters in the Niagara District 1976-77 (Buckingham, 1977?). If the weights reported for Ontario are carcass weights instead of body weights, and if the same relationship between skinned carcass weight and whole body weight holds in Ontario as in Missouri (Fritzell et al. In Press), juvenile raccoons in Ontario weighed about 0.5 lb less than juvenile raccoons in west-central Illinois, and adult raccoons in Ontario weighed about 1.0 lb more than adults (of both sexes) in west-central Illinois.

DISTRIBUTION

"The raccoon (Procyon lotor)...ranges across the North American continent, except in parts of the Rocky Mountains, from well into Canada to as far south as Panama." (Sanderson 1983:485.) Procyon was originally found only in the New World; however, raccoons were introduced into Russia in 1936 and by 1964 had increased to an estimated 40,000-45,000 (Aliev and Sanderson 1966). This species was also introduced into Germany in 1934 and

now occupies a large portion of West Germany (Aliev and Sanderson 1966). de Beaufort (1968) reports several records of raccoons from France.

"In North America, raccoon populations had declined to low levels by the 1930s. A continentwide population explosion began with the 1943 breeding season (Sanderson 1951a, b; Keefe 1953). The rapid increase in numbers continued into the late 1940s, and high population levels have been maintained since that time. It is conservatively estimated that there are fifteen to twenty times as many raccoons today as there were in the 1930s. With the increase in numbers, raccoons extended their ranges to include areas where they were absent or rare during the 1930s; for example, sandy prairies in Illinois, desert areas, and coastal marshes. In addition, they extended their range many miles to the north in Canada (Sowls 1949; Mann and Gunn 1956). The raccoon is at present reported so far north in Canada that native Indians have no name for it." (Sanderson 1983:485)

Goldman (1950:24) indicates the range of *P. l. lotor* along the southern border of Canada west to the middle of Ontario, *P. l. hirtus* extending west to the southeast corner of Saskatchewan, *P. l. pacificus* along the southern border in southwestern British Columbia, and *P. l. vancouverensis* on Vancouver Island. Hall (1981:971) shows some extension of *P. l. lotor* into southeastern Canada, with the dividing line between *P. l. lotor* and *P. l. hirtus* just east of the westernmost part of Lake Superior in Ontario. The major extension of the raccoon into Canada as shown by Hall (1981) is *P. lotor hirtus* north in Ontario nearly to Hudson Bay and then west across Manitoba and Saskatchewan and most of Alberta. He shows *P. l. excelsus* extending barely across the border into the extreme southeastern corner of British Columbia, *P. l. pacificus* along the

southern border of British Columbia, and P. l. vancouverensis on Vancouver Island and several smaller islands, including several where it has been successfully introduced.

The raccoon has a relatively long history in Canada. Hewitt (1921) reported fur records of Hudson's Bay Company, 1921-1914. He presents a graph of the raccoon harvest that shows practically no raccoons from 1821 through 1835. In 1836, approximately 2,000 were reported, and the trend was gradually upward to about 4,000 in 1863. In 1864, approximately 2,000 were reported, numbers increased to a peak of about 21,500 in 1868, then declined to about 2,000 in 1870. There was another peak in numbers in 1900. Soper (1923:251), writing about Wellington and Waterloo counties, Ontario, reported the raccoon as, "Still more or less commonly distributed, though of late years much reduced. In the wilder sections of southeast Wellington quite a number still occur." Innis (1927:267-268) reported that in 1805 exports to the U.S. "Included 21,115 pounds beaver and 28,379 marten, 10,427 otter, 128,837 muskrat, 21,776 raccoon." Soper (1942) reported a raccoon taken about 1931 in Wood Buffalo Park, northern Alberta, and reported the raccoon as very rare there. Eklund (1946) reported from 5,120 to 7,486 raccoon pelts taken per year in British Columbia from 1926 through 1929; from 1930 through 1942 the average annual take was 2,661.

Rand (1943:95), discussing the early history of the raccoon in Nova Scotia, wrote, "It appears that sometime before the arrival of the European in Canada raccoons were common and widely distributed over the mainland of Nova Scotia, not only in the Transition Zone of the Annapolis Valley, but through the Canadian Zone as well, to be common at Mahone Bay. It apparently existed up until the beginning of the seventeenth century when Lescarbot recorded it with its Indian name.

"Evidently then it disappeared and the Indians lost all knowledge of it including the name. In Gilpin's time (1870) it was reappearing again and is now fairly common over parts of the province.

"Such evidence and similar evidence for the white-tailed deer, should be carefully considered when evaluating the balance of nature and in broad views of conservation. Certain animals have evolved, flourished and waned, perhaps with successive periods of abundance without aid or hindrance from man. We have no evidence the process has stopped."

Soper (1946:311) reported that P. l. hirtus, "Once ranged widely and rather commonly over southern Manitoba but it is now rarely met with and in many districts has become exterminated." Sutton (1964), discussing the raccoon in Manitoba, stated, "This relatively scarce species not only has become numerous, but has extended its range into northern areas where it was previously unknown." He said that by 1958 it had become so abundant that farmers were asking for relief from its depredations. He also confirmed records of the raccoon as far north as 52° latitude, stating that these records were from as far north as Seton had reported for the species some 50 years earlier. Lynch (1971:622) wrote, "Numbers of native raccoon pelts marketed in Manitoba increased noticeably beginning with the fur season of 1954-55. From the season of 1959-1960 to that of 1966-1967, annual production remained near 700, except in 1964-1965, when 375 pelts were marketed; from 1966-1967 on, there was a definite increase."

Jameson (1943) reported the raccoon as common in Welland County, Ontario. In Ontario, Peterson and Crichton (1949:75) reported, "The raccoon is a rare animal as far north as the Chapleau district. None was sold on the market from this area, although one was shot along the Wakami River in Benton Township in November, 1946, by a resident of Chapleau and

examined by us. It was reportedly mistaken for a 'young wolf' and the pelt turned in to the Chapleau district office." Lumsden (1956) said that the sport of raccoon hunting at night with dogs was officially recognized in Ontario in 1950 with the issuance of a license. Simkin's (1966:145) paper reports, "15 records of raccoons from areas which are north or northwest of any included in the literature relating to the species distribution in Ontario." He further reports (1966:146), "It does not appear that there has been a large scale invasion of raccoons to the north during any one year, rather, there have been sporadic occurrences of single individuals over a long period of time. There is also no evidence available to indicate that there is an established population anywhere in northwestern Ontario at the present time except in the Rainy River region."

Apparently, in recent times, the raccoon was not abundant in Saskatchewan until fairly recently. Mann and Gunn (1956:27) reported four raccoons taken in early winter on Bear Creek, and "Joyce Gunn from Spirit Lake also reports a Raccoon that arrived in their yard January 21, taking refuge in the garage. When she wrote on January 26, the Raccoon was still sheltering in the garage, thriving on a diet of fish, table scraps and bread and milk. The Gunn family settled at Good Spirit Lake in 1887, and this is the first record that they have of a Raccoon in the district." Fox (1958:179) reported an adult raccoon, on 1 September 1958, 3 miles east and 1.5 miles south of Kindersley, Saskatchewan, and Durr (1958:80) trapped a raccoon on Long Creek, Saskatchewan, "this winter." His father homesteaded there in 1903, and this was the first raccoon he had seen in that area. Francis (1959:30) saw a raccoon "about ten years ago" at a fur buyer's in Nipawin. He also reported the presence of a raccoon on his farm on 20 October 1958 and in the Yorktown area "last summer." He believed the

raccoon to be widely distributed and perhaps increasing in all areas of Saskatchewan and states that reports (from the Department of Natural Resources) show a total of 177 raccoon pelts taken in 8 years, 1950 through 1957. Houston and Houston (1973:103-104) wrote, "On four trips in 1972, we saw a total of nine dead raccoons on Saskatchewan roads. Since we had not ourselves seen a raccoon, dead or alive, in our many thousands of miles of travel yearly, this suggested an increase in the numbers of this species." They reported, from the annual "Statement showing the number and kinds of furs bought in Saskatchewan" the following average number of raccoons per year: 1931-40, 10; 1941-50, 26; 1951-60, 33; 1961-70, 122; and 1971-72, 232.

REPRODUCTIVE BIOLOGY

Except as noted, information on the reproductive biology of the raccoon is summarized from Sanderson and Nalbandov (1973:79-81) and refers to the raccoon in Illinois.

Males

In Illinois testes of raccoons grow at a uniform rate from birth until about 10 months, when the average weight of one testis is 5.6 g (Fig. 1). Male raccoons usually reach sexual maturity as yearlings but become sexually potent about 3-4 months later than adults. Despite statements to the contrary in the literature, male raccoons are not sexually active the year round, and average testis weight varies. Testes have minimal weights in June-August and reach maximum size in December-- variation from minimum to maximum weight is 2.8 times. There is a positive correlation between testis weight and sperm in the epididymis, but the weight of the testis does not indicate the capacity to breed. Sperm may be found in the

epididymides of some raccoons in all months of the year, but individual males always had periods, averaging 3-4 months, when they had no sperm.

Females

Ovaries grow at a generally steady rate from birth in April through the following November (Fig. 2). Maximum ovarian weights are found in young-of-the-year females in November, which is about 3 months before the peak breeding season. The ovaries of young-of-the-year females declined in weight from November through January and perhaps through March. Weights of ovaries of adults followed a seasonal pattern similar to that found in the weights of testes of adult males; minimum weights in July, a slow increase until November, a decline from November to December, and an increase to an annual peak weight in April, when ovaries were slightly heavier than they were in November. Average peak weights of ovaries are about 1.6 times minimum weights in July. Junge and Sanderson (1982) reported that in 1979, 73% of female raccoons in west-central Illinois mated before they were one year old, and Fritzell et al. (In Press) reported from 38% through 77% of female raccoons in Missouri (1979 through 1981) bred before they were one year of age. Fritzell et al. (In Press) found from 59% through 73% of females in northern Illinois (1979 through 1981) mated during their first year.

Birth Dates

Twenty litters conceived in the wild in Illinois had a mean birth date of 18 April, range 9 March-24 June, and 11 litters conceived and born in captivity had a mean birth date of 24 April, range 16 March-3 June. Reports from the literature indicate earlier mating in the north (February to June in Manitoba, North Dakota, and Minnesota; Schneider et al. 1971, Cowan 1973, and Fritzell 1978a) than in the south (March in Louisiana,

Cagle 1949, and Georgia, McKeever 1958, and in Alabama from March through June or later, Johnson 1970).

Estimating Date of Birth

Measurement of the largest external dimension of embryos in the uterus permits estimation of the birth date with a maximum error of 4 days (Sanderson and Nalbandov 1973:47) (Fig. 3).

Sex Ratios

Sex ratios of embryos, young at birth, and young less than 2 months of age were not significantly different from 50:50; however, there were more males among young less than 2 months of age than among embryos. Thus, there might be a somewhat higher mortality of females than of males between birth and 2 months of age.

Ovulation

The raccoon is a spontaneous ovulator, with ovulation invariably followed by pregnancy or pseudopregnancy and the formation of corpora lutea. The formation of corpora lutea is always followed by enlargement of the nipples, some remaining unpigmented and others becoming lightly or heavily pigmented with black. Thus, examination of the nipples will identify females that have ovulated. Corpora lutea persist until parturition in pregnant females and disappear about 14-16 days after parturition. Corpora lutea persist in pseudopregnant females for about the same length of time as in pregnant females. About 2.5% of adult females become pseudopregnant each year in Illinois. Yearling females either ovulate and become pregnant or pseudopregnant at about the same time as adults or do not breed until their second year.

Gestation

The gestation period is approximately 63 days.

Multiple Litters

There are numerous speculations in the literature as to the possibility of raccoons having two litters per year; however, arithmetic will demonstrate that in most situations there is not enough time for a female raccoon to rear two litters in one breeding season. The gestation period is about 63 days, young are born with their eyes closed, and these do not open until about 21 days. Young begin to move with the female at about 9 weeks of age (Sanderson 1961) and nurse for 8-16 weeks (Montgomery 1969). Young raccoons typically remain with their mothers through the first winter, and I have no evidence and have seen no evidence in the literature that a female with young ovulates. If we assume that raccoons could survive without their mothers at weaning, that the peak of breeding in Illinois is the middle of February, and the peak for the birth of litters is the middle of April, the peak of weaning would be the middle of July to the middle of August. If a female bred for the second time the first of August, the second litter would be born about the first of October and would not begin to move with the female until around the first of December, when they would weigh 2 lb each (Sanderson 1961). Rarely are raccoons weighing less than 4 lb each found during the hunting and trapping seasons (usually early November to about the middle of January) in Illinois. Also, I have seen no evidence that a raccoon will ovulate a second time in one year unless the second ovulation follows pseudopregnancy or the loss of a litter by absorption or abortion prior to birth or by the death of the young at or shortly after parturition. Thus, two surviving litters by one female in a single year are theoretically possible in the wild and have been induced in captivity (Millard 1939), but I doubt that they occur in the wild, and, if they do, it probably is in the extreme

southern portion of the range. It has been demonstrated (Millard 1939, Sanderson and Nalbandov 1973) that raccoons in captivity can be induced to give birth to two litters in a single season. There is considerable circumstantial evidence that wild females occasionally give birth to late (second) litters in the same season (Dorney 1953).

One learns by experience to "never say never" regarding biological phenomena; however, it is safe to say that raccoons rarely if ever rear two litters in one season in Ontario. If they do, it is so rare as to have no significant effect on the population.

Placental Scars

Sanderson and Nalbandov (1973:65) state that, "Placental scars of raccoons are useful for estimating the litter size and rate of productivity. However, these scars must be used with caution, and care must be taken to separate properly the groups of scars (Fig. 4). We can say with reasonable confidence that each embryo that reaches 1 month of age is represented by one scar for 10 or more months. Scars in wild females with only one group of scars probably reflect implantation rates for the preceding breeding season. Most single groups of scars occur in females that have mated successfully only once. Sanderson and Nalbandov (1973) present a general discussion on placental scars in the raccoon.

We use scars in uteri with only one size and density of scars, plus the larger and darker scars in uteri with two groups of scars, for determining average litter size. Pale scars in uteri with two groups of scars may represent litters from a previous season or an earlier litter from the same season that was aborted or resorbed or died at or near birth, the female having conceived for a second time in the same season. Junge and Sanderson (1982) found that nearly 30% of the parous females they

examined that were less than 1 year old had two groups of placental scars. It was surprising to them that this high percentage of young-of-the-year females had "lost" first litters by one means or another and had conceived a second litter the same year. Slightly more than 45% of the adult parous females they examined had two sets of placental scars.

Sanderson (1984) reports a 29-year average of 2.61 pale scars per uterus, 3.56 dark scars (or scars in uteri with only one group of scars) per uterus (believed to be average litter size), and 4.36 scars per uterus with one or more scars. Buckingham (1977?) reports "Mean litter size over all age classes averaged 3.9...." But it is not clear to me from the report if this is based on all scars per uterus or only dark scars and single groups of pale scars.

Morphology of Reproductive Tracts

Sanderson and Nalbandov (1973:65-66) described the reproductive tract of the male: "The duct system and accessory glands in the reproductive system of the male raccoon...are similar to those found in the dog, as described by Nalbandov (1958:42-44). Seminal vesicles are lacking, as they are in the dog, fox (Vulpes fulva), and wolf (Canis lupus). The Cowper's glands (bulbo-urethral glands) are also absent. The walls of the vasa defenentia thicken prior to entering the prostate and form the ampullae. The ampullae and the urethra unite inside the prostate to form a common duct. The many compartments of the prostate gland open into this duct system.

"The os penis or os baculum (bone of the penis) is well developed in the raccoon."

Fig. 5 shows a schematic drawing of the reproductive system of an adult male raccoon.

According to Sanderson and Nalbandov (1973:66), "The raccoon uterus...is somewhat intermediate between the bicornuate uterus found in the pig and insectivores, and the bipartite uterus found in the cat and dog. There is a single cervix and the horns are distinct, but after the horns join externally to form the single, small uterine body, the uterine lumina remain separate--even though this separation is not apparent from the outside--to a point near the cervix."

The ovary (Fig. 6) is ovoid and completely surrounded by the bursa ovarii. The sac surrounding the ovary is complete except for a small slit on one side, which is not large enough to permit passage of the ovary as in the fox, dog, and mink. There is an extensive fimbria, which in the estrous female is bright red and protrudes through the slit in the bursa ovarii.

See Sanderson and Nalbandov (1973:65-66) for a more complete discussion of the morphology of the male and female reproductive tracts in the raccoon.

ECOLOGY

Habitat

Throughout their range raccoons are usually most abundant near water, especially in bottomland forests along streams, hardwood swamps, flooded timber around reservoirs, marshes, and mangroves. Populations are low in southern pine forests, deserts, and mountains above 2,000 m (Kaufmann 1982:71). As mentioned under DISTRIBUTION, with the increase in abundance that began in the early 1940's, raccoons moved into plains, prairies, deserts, and farmland where trees and water are scarce. In the Midwest, raccoons are commonly found using ground dens; piles of rubbish, brush, lumber, etc; corn cribs; machine sheds; haylofts;

attics; chimneys; walls in homes; and similar sites for both winter dens and for rearing young. Raccoons using homes for denning at farmsteads and in towns, villages, and cities in Illinois and other midwestern states result in many calls to natural resource agencies for advice and assistance on how to remove the unwanted visitors. In situations devoid of natural supplies of water, raccoons do quite well utilizing sources of water intended for livestock, bird baths, swimming pools, and irrigation.

Sex Ratios

Data collected for 29 seasons (1955-56 through 1983-84) in west-central Illinois show that young-of-the-year animals contributed 66.5% to the female harvest and 69.0% to the male harvest. Females constituted 46.7% of the harvest of young-of-the-year animals, and young-of-the-year animals 67.8% of the total harvest (Sanderson 1984). These figures show annual differences of up to 20% for the 29-year period, depending on weather, number of animals taken by hunters and trappers, and other, but unknown, factors. The figures have shown no trends during the 29-year study. Sex ratios have ranged from 42.5% (1955-56) to 51.1% females (1964-65) and have averaged 48.0% females during the 29 years of this study.

Body Weight

Body weights of raccoons have little meaning unless separated by sex and age classes. Weights have varied by approximately 1 lb from one season to the next in west-central Illinois during the past 29 seasons but have shown no trend (Sanderson 1984). The lack of any trend in body weights indicates no shortage of food for the population levels encountered during the period of study. Average weights of 4,704 young-of-the-year males was 5,151 g (11.4 lb) and varied from 4,588 g (10.1 lb) to 5,713 g (12.6 lb); for 4,154 young-of-the-year females, the average weight was 4,806 g (10.6

lb), and the range was 4,189 g (9.2 lb) to 5,305 g (11.7 lb). Adult males (2,115) averaged 7,554 g (16.7 lb), with a range from 6,955 g (15.3 lb) to 8,274 g (18.2 lb). Parous females (1,728) averaged 6,429 g (14.2 lb), with a range from 5,586 g (12.3 lb) to 7,073 g (15.6 lb), and nulliparous adult females (361) averaged 5,985 g (13.2 lb) and ranged from 5,137 g (11.3 lb) to 7,150 g (15.8 lb).

Data collected at fur houses must be used with care. It must be understood that raccoons brought to fur houses by hunters and trappers probably do not accurately represent the composition of the wild population. Young animals are generally more vulnerable to hunters and trappers than are adults, parous females travelling with their young are more vulnerable to hunters and cars than are nulliparous adult females, and late in the season, when they are sexually active, males move more than females and are thus more vulnerable to capture than are females. If cold weather comes early, in that season there will be a disproportionate percentage of young-of-the-year animals of both sexes and of parous females, if the weather is unusually mild in January, while the hunting season is still open, the harvest will be high in sexually active adult males. Colder than average weather will restrict the movements and feeding of raccoons and will result in a higher than average decline in body weight. When the price of pelts increased, the percentage of very small young animals in the harvest increased. When prices were low, buyers often refused to purchase the very small young at any price, and if killed by hunters and trappers, the small young animals were discarded.

Movements and Home Range

Movements and home ranges of raccoons vary according to sex and age, habitat, food sources, season, and other factors. In general, males have

larger home ranges than females have, home ranges of adults with young are restricted, and movements in winter tend to be less extensive than they are at other seasons. Ellis (1964:366) found a female whose "only movements during those 3 nights were her trips to hog feeders and watering troughs about 30 yards away." He believed these were the first 3 nights after the female had given birth. He also reported that the movements of 3 raccoons were affected by available sources of corn.

Stuewer (1943), Butterfield (1944), and Urban (1970) presented evidence that juvenile raccoons disperse from their natal areas in fall or winter. In the northern portion of the raccoon's range, such dispersal may occur in spring or summer of the year following birth (Schneider et al. 1971, Cowan 1973, Fritzell 1978a). Kaufmann (1982:573) summarized sizes of home ranges of raccoons: "Most of the maximum home range diameters that have been reported fall between 1 and 3 km, with a few of up to 6.4 km (Stuewer 1943a; Butterfield 1944a; Cunningham 1962; Turkowski and Mech 1968; Sunquist et al. 1969; Urban 1970; Johnson 1970; Schneider et al. 1971). Hoffman and Gottschang (1977) reported range diameters of only 0.3 to 0.7 km in a dense suburban population, while Fritzell (1978b) found ranges up to 10 km across on the North Dakota prairies. Similarly, the areas calculated for raccoon home ranges vary from less than 5 ha in the Ohio suburbs to almost 5000 ha in North Dakota, with most falling in the 40- to 100-ha range elsewhere."

Activity

Raccoons are active mostly at night; however, they may change their activity periods to accomodate the availability of food and water. Ellis (1964) reported that the main feeding activity was mostly before midnight. Ivey (1948:290) found a different pattern of activity in the salt marshes.

"Salt marsh raccoons take advantage of the abundant food supply exposed on mud banks, beaches, and stream bottoms at low tide. This food is composed primarily of crustaceans and mollusks. With food so readily available, raccoons apparently become adapted to a specialized schedule which consists of activity at low tide and inactivity at high tide, almost without regard for day or night...." Moore (1953) found raccoons digging "wells" along the Florida coast, some of these were dug in the sand to get fresh rainwater that was lying on top of the heavier sea water. The heaviest use of these wells was at mid-day.

During periods of cold weather, wild raccoons often share dens, presumably to help conserve heat. In many instances when 3-5 raccoons are found sharing a den, it will be one adult female and young-of-the-year animals; presumably offspring of the female. With larger numbers of raccoons in one den, both sexes and juveniles and adults may be represented. I have taken as many as 12 raccoons from a single tree den in Missouri during cold weather. In the Midwest, raccoon hunters often remove several raccoons from haylofts, corncribs, and other buildings at the request of farmers. These animals are usually taken during cold weather when raccoons are moving little, if at all, at night, and the hunters are not night hunting. Mech and Turkowski (1966) reported 23 raccoons taken from one den in Benson, Minnesota, on 1 January 1966. The 23 animals included 8 adults and 15 young; 5 of 12 females were parous.

BEHAVIOR

"The one thing that most people 'know' about the raccoons is wrong. This 'known fact' is that they always wash their food. Not true! I have not observed wild raccoons 'washing' their food before eating it, although a tame raccoon allowed to capture wild animals for food will sometimes

'wash' them before eating. 'Washing' is a trait of captive raccoons, but many captives pick food from the feeding dish and place it directly in the mouth with no intermediate steps. Even those captives that apparently wash their food are in fact feeling it. Perhaps dipping something (food or an unfamiliar item such as a nail or marble) in water makes the pads of the raccoon's 'hands' more sensitive. In any case, captive raccoons often 'wash' unfamiliar items without benefit of water. Studies have shown highly developed nerves in the hands of the raccoon (Sanderson 1983:486)." Lyall-Watson (1963) suggests using the term "douse" instead of "wash" to describe this activity in the raccoon.

The raccoon is high on the intelligence scale of wild animals, and it has been studied rather intensively in this area. Cole (1912) reported that the sense of touch was the most conspicuous behavior of raccoons; both the hands and nose were used for touch. He said that the sense of smell was not often employed, but that the raccoon has keen senses of sight and hearing. Cole (1907) in an earlier report concluded that raccoons are either much more clever than cats or the methods used were better for showing their latent possibilities. Raccoons learned quickly and seemed to retain images in their minds; there seemed to be proof that raccoons have ideas. In this same study, Cole also found that raccoons could discriminate between squares that were 6.5 and 4.25 inches and among polished cubes and cylinders that were identical except for size--1.0, 0.5, 0.25, and 0.125 inch.

Barash (1974) livetrapped male raccoons and red foxes and exposed them to each other in captivity. In both species, animals that were trapped closer to each other showed a higher frequency of dominant-subordinant relationships and fewer intensive aggressive interactions than animals

trapped farther apart. This evidence suggested to him that neighbors recognized each other and the existence of a rudimentary social structure in these "solitary" species.

Ough (1982:318) studied scent marking in captive raccoons and speculated that "Urination and defecation could constitute scent marking because pheromones might be present...." He also reported that, "Use of communal defecation sites is characteristic of raccoons.... Although function of communal sites is presently unknown, intraspecific olfactory communication represents the most probable explanation."

Kaufmann (1982:575) states that, "Consistent with their nocturnal habits, raccoons are color blind (Davis 1907, Michels et al. 1960), but have excellent night vision. A well-developed tapetum behind the retina produces at night as (sic) bright red eyeshine with flashes of green from some angles." Davis (1907) reported that raccoons quickly learned to open fasteners to obtain food and that they remembered the solutions learned for a year or more without practice. Johnson (1957) concluded that raccoons were better at learning set formations than any species other than the higher monkeys and apes and man. He also found (Johnson 1970) that raccoons passed learned behavior to succeeding generations through cultural inheritance.

In routine movements, the raccoons have a slow, flat-footed walk; however, when pursued they can run rapidly, by a galloping gait, for considerable distances. In open areas, I have been able to outrun adult raccoons and capture them; however, raccoons would often make several successful dodging maneuvers first. If brush or debris is present, raccoons can usually outmaneuver a man on the ground and avoid capture. Raccoons routinely descend trees head first but can also back down. On

sunny days in winter raccoons often lie on large limbs or on top of leaf nests of fox and gray squirrels. If a squirrel nest with a raccoon can be shaken vigorously enough via an attached grapevine, or the raccoon approached by a climber, it often first urinates and when disturbed further will jump from a considerable height to the ground and land running. I have not observed a raccoon to be injured by jumping from a tree.

Raccoons use their hands to find food, both on land and in water. I have observed raccoons searching for food in the water while apparently gazing into the sky. Once a food item is caught or found, it may be examined visually while being manipulated with the hands before being eaten. Wild raccoons often defecate and urinate in "latrines" but single scats are also common. As indicated earlier in the present report, raccoon latrines may serve as scent stations (Ough 1982).

Raccoons utter a variety of vocal calls. Young raccoons separated from their mothers or otherwise distressed give a call that sounds to me similar to the call of the tree frog. The young also give a quiet "churr" to indicate contentment. During fights and other extremely stressful situations, raccoons scream, hiss, snarl, and growl. Visual displays include raising the shoulder hackles, laying back the ears, raising and lashing the tail, baring the teeth, arching the back, and moving sideways in a more or less circular motion in a series of short jumps or hops.

Other than females and young, which tend to move as a family group, and pairs during the breeding season, raccoons tend to be solitary when not denning, except when feeding at a concentrated food source. As mentioned earlier in the present report, several raccoons often den together during very cold weather.

FOOD HABITS

The raccoon is one of the most omnivorous of animals; it will eat carrion, garbage, birds, mammals, insects, crayfish, mussels, other invertebrates, a wide variety of grains, various fruits, other plant materials, and most or all foods prepared for human or animal consumption. Dearborn (1932) reported on foods of raccoons in Michigan, based on the collection of scats, mostly in 1930. The percentage volumes were crayfish, 59%; oats and corn, 20%; cherries and berries, 12%; rabbits and mice 1%; mollusks, 1%; and poultry, eggs, snakes and turtles, frogs, fish, and insects all represented at less than 1% each. Giles (1940) reported corn as the postwinter staple food in eastern Iowa, grass and beetles being important in early summer. Beetles remained important until the middle of July and were again important from the middle of August until the next summer. In his study, 77.7% of the bulk was vegetable matter and 22.3% animal matter. In central Iowa (Giles 1939), 67 fresh scats collected between 14 September and 14 November showed that corn, crayfish, and hackberries together made up 87.5% of the total fecal material. Corn was 27.7% in September, 31.3% in October, and 83.3% in November.

Tyson (1950) reported summer food habits of raccoons in southwest Washington; mostly animal food that was found along the mud flats was present. The absence of plant food was noteworthy. Dexter (1951) reported unseasonably warm weather during January and February 1949 and 1950 in Ohio The stomach contents of two raccoons captured in January and February 1939 consisted of 20 and 50% earthworms, respectively, and stomachs from eight raccoons trapped during the first week of January 1950 had 50% frequency of occurrence and 12.6% of the volume in earthworms. Schoonover and Marshall (1951) collected 135 scats in the summers of 1948 and 1949 in

north central Minnesota. Crayfish, June berries, grasshoppers, and acorns were taken in greatest quantity and accounted for 76.3% of the total volume. Llewellyn and Uhler (1952) examined 520 samples of stomachs and scats from raccoons that were reasonably distributed throughout the year. Plant material constituted 48% of the total. In summer, fall, and early winter, plants provided the bulk of the material. The use of plant materials increased in June and July, reached a high in November, and then declined through March. The principal plant items were corn, 8%; wild grapes, 8%; wild black cherry, 7%; acorns, 8%; persimmon, 4%; pokeberries, 4%; and blackberries, 3%. The 52% animal material included well over 100 items, the greatest volume of animal matter occurring in late winter and spring, and in late winter many raccoons depended largely on insects. Insects were important as food during most of the year, and beetles made the largest contribution. Tester (1953) collected 97 scats and three digestive tracts from raccoons along the South Platte Valley of northeastern Colorado in November and December 1951. Plant material constituted 73% and animal matter 27%. Of the vegetable matter, corn made up 82.5%, and plums, cherries, and grapes were the only other plant foods making up 1% or more. Insects were 13.1%, grasshappers being the most important. The frequency of occurrence of crayfish was 2 times as high as that of grasshoppers, but the total volume was slightly smaller than grasshoppers; small mammals were 2% of the total volume. Wood (1954) studied the food habits of raccoons in the upland post oak region in Texas. Plant food made up over 50% of the annual diet; insects were second, followed by mammals, invertebrates other than insects, cold-blooded vertebrates, and birds. Cottontails were taken more frequently than any other mammal. Shabica et al. (1978) reported raccoon predation on sea turtle nests. Wilson (1956) reported raccoon predation on

muskrats in North Carolina. Llewellyn and Webster (1960) reported raccoon predation on waterfowl.

Greenwood (1981) studied the food habits of prairie raccoons during the waterfowl nesting season. Plant foods occurred in 84% of the scats, wheat and barley being consumed most frequently, but corn and sunflowers also being consumed. Wheat and barley in this area took the place of corn and mast in the diet of raccoons in the southern and eastern regions. Animal residues occurred in 86% of the scats, birds in 34%, and eggs in 29%. Ducks averaged 5% occurrence, coots 6%, duck eggs 11.7%, and coot eggs 4%.

TECHNIQUES FOR SEXING AND AGING

Sanderson (1961a) reported techniques for determining ages of raccoons. These included body weights of young, closure of epiphyses in the radius and ulnae (examined visually in cleaned bones or by x-ray of live animals), bacula of males, extrusibility of the penis in males, and stimulation of the nipples in females. In general, these techniques separate animals into two age classes--juveniles and adults. Montgomery (1964) discussed tooth eruption for aging preweaned raccoons, and Sanderson (1961b) presented information on using the dry weight of the lens for determining ages of raccoons. More recently several techniques have made it possible to separate raccoons into several age classes. Grau et al. (1970) used tooth sectioning to separate raccoons into 8 age classes: young-of-the-year, 1, 2, 3, 4, 5, 6-7, and >7 years. Junge and Hoffmeiseter (1980) used obliteration of cranial sutures for age determination by 2-month periods through 50 months of age. By 122 months of age, all sutures were closed.

Sex is readily determined in living and dead raccoons by the presence of testes, which are always descended, penis bone, and preputial orifice in

the male and the absence of these and the presence of the vulva in the female. Sex can be determined in early stages in the embryo by the outline of the penis bone in the male as well as the greater distance between the anus and urinary opening in the male. As was mentioned earlier in the present report, raccoons that become agitated enough to jump from leaf nests of squirrels or from tree limbs when pressed closely by a human climber, often urinate before they jump. It is usually possible to determine the sex of such a urinating raccoon by noting the source of the urine.

The sex of cased raccoon pelts can sometimes be determined by noting the location of the dried preputial orifice in males and of the dried vulva in females. However, when cased pelts are scraped, they are sometimes torn when the scraping knife catches on the dried tissue at the locations of these previous openings. Pelts on which sex cannot be determined are more likely to be from males than from females. Thus, I do not recommend determining sex ratios from raccoon pelts. Sex can be determined for skinned carcasses by the presence of the baculum, or the site at the base of the baculum where the penis was cut through if the baculum is missing, and the vulva in carcasses from females. If there is any problem with the external determination of sex in skinned carcasses, the ovaries and uterus are readily located and identified even in a small female.

METHODS FOR CENSUSING POPULATIONS

Clark and Andrews (1982) report that in the north-central region of the United States and adjacent regions in Canada, one or more states and provinces were using these techniques as indices to raccoon populations: fur dealer reports, trapper questionnaire, road mortality samples, scent-post samples, spotlight samples, and impressions of field personnel.

The general nature of these techniques indicates that techniques for accurately determining numbers of raccoons are not available. Fortunately, for most purposes--for example, for managing raccoons on a statewide or provincewide basis--general population trends, which can be determined by a variety of techniques, are adequate. Some of the techniques in use for estimating raccoon populations and population trends are discussed here.

Scent Stations

Sumner and Hill (1980:575) used scent stations to obtain an index to the abundance of raccoons in Alabama. They felt that "Mid-winter scent-stations may not accurately reflect raccoon population densities." They suggested that upland sites run between April and October better reflected raccoon populations than did midwinter scent stations. If used in midwinter, they suggested scent stations be placed beneath bridges or at stream crossings. Conner et al. (1983:149) studied scent stations as an index to abundance of raccoons in Florida. They reported that, "changes in the scent-station indices probably reflected changes in raccoon abundance between habitats...." Evidence from these studies indicates that scent stations are probably adequate to indicate gross population levels among areas and among years, but do not actually census populations.

Direct Counts

Twichell and Dill (1949) removed 100 raccoons from 102 acres on a waterfowl refuge in Missouri during winter. Such a count gives precise numbers, but one is left wondering how many raccoons were missed and how large an area the animals covered when not denned during cold weather. Fountain (1976) used an airboat and a johnboat to collect and count raccoons in a tidal marsh. He reported 304 raccoons seen and collected (shot with a .22 rifle or caught in a dip net) in 68 man hours with the

airboat as compared to 62 seen and collected in 56 man hours with the johnboat. More raccoons were seen and collected at high tide than at low tide.

Spotlight Censuses

Rybarczyk (1978) developed a spotlight survey technique as an index to the abundance of raccoons. This technique is being used and refined in Iowa, Illinois (Andrews 1979, Rybarczyk 1981, Rybarczyk et al. 1981, Clark and Andrews 1982, and Hubert 1982), and perhaps in other states. The technique seems to have considerable promise for providing indices to raccoon populations. The spotlight census is 25 miles in raccoon habitat; a driver and observer drive each route, using 100,000-candlepower spotlights; counts are made (in Iowa) between 10 and 30 April (10-14 days prior to leaf out in spring). The count is made in the evening, when relative humidity is 60% or higher, but not during heavy rain, mist, or fog or when the wind is more than 10 mph. The count is made only when temperatures are above freezing and is begun 1 hr after sunset. The driving is at speeds of no more than 10-15 mph, and the driver and observer each count on his or her side of the vehicle and stop to make positive identification of each animal when necessary.

Mark and Release

Sanderson (1951a) livetrapped raccoons, placed a tag in each ear, toe-clipped the animals for individual recognition, and released them. Returns were obtained from hunters, trappers, and furbuyers; however, returns were too meager to provide valid population estimates. Later in Illinois (Sanderson unpublished), I conducted a similar study for several years, but returns were again too uncertain to use for calculating population levels; however, movements and recaptures over a long period of

time were sufficient to allow a minimum population estimate for the study area. Conner and Labisky (1984 in Press) report on the use of radioisotope tagging as a technique for estimating the abundance of raccoons, but I have not seen this report. Radiotracking of a sufficient number of raccoons can also result in population estimates.

Furbuyers' Reports

One of the oldest methods of keeping track of raccoon populations is reports from furbuyers. Seton (1909:104) and Hewitt (1921:233) present figures for the raccoon harvest that show that the raccoon population curve is of the irruptive type. Sanderson (1951b), in discussing the status of the raccoon in Iowa, stated, "It is believed that these fur reports are unusually complete, and since the hunting and trapping regulations have remained the same throughout the 20-year period, it is felt that the figures obtained are particularly valuable as an aid in understanding the population trends of Iowa raccoons. The limitations of fur reports as an index to fur populations are too well known to warrant further discussion." That study showed little relationship between average pelt value and annual harvest rate. Thus, I believe that raccoon harvest figures, especially in the Midwest where raccoon hunting is a popular sport, reflect population trends better than they do for any other species. The exceptionally high prices paid for raccoon pelts during the past few years (an average of $27.25 per pelt in Illinois for the 1978-79 season [Hubert 1983], with some individual pelts bringing as much as $60) may have more effect on the number of raccoons taken by hunters and trappers than prices did in earlier years (Sanderson 1951b).

METHODS FOR DETERMINING PRODUCTIVITY

Sanderson (1950:389) wrote, "Indices of abundance and productivity are

needed if raccoons are to be fully studied and managed. These indices may be sought in the sex and age composition of the harvest as well as in the number of young produced per adult female...." However, at that time techniques for collecting adequate data on the sex and age composition of raccoons were only being developed, and most of that paper dealt with techniques for determining the age of raccoons and for determining litter size. At present, relatively satisfactory techniques have been developed for determining sex, age, and litter size in raccoons (see the sections on REPRODUCTIVE BIOLOGY and TECHNIQUES FOR SEXING AND AGING in the present report). Sanderson and Hubert (1981) presented sex ratios, age composition, litter size (from placental scars), and body weights of raccoons from west-central Illinois from 1955-56 through 1979-80. Sanderson (1984) extends these data through the 1983-84 season, and reports the 29-year averages as litter size, 3.6; young-of-the-year, 67.8%; young-of-the-year per parous female, 5.1; females among all adults, 45.6%; females among all young-of-the-year, 46.7%; females among all raccoons, 48.0%; body weight for young-of-the-year males, 11.4 lb; young-of-the-year females, 11.6 lb; adult males, 16.7 lb; parous females, 14.2 lb; and nulliparous adult females, 13.2 lb. Body weights during this 29-year period vary as much as 2.8 lb from year to year, but annual variation was usually less than 1.0 lb and the weights showed no trends. There were small annual variations in all other categories reported but no trends. Sanderson (1984:1-2) concluded, "If the data collected are indices to major changes in the population, they do not indicate such changes in the raccoon population in west-central Illinois. However, these data probably would not reflect a major change in the population until the year after the change occurred."

In a recent study (Junge and Sanderson 1982), it was learned that 73% of the yearling females in Illinois had mated and that nearly 30% of the yearlings had two sets of placental scars. These authors were surprised at the relatively high percentage of yearling females that had lost first litters by resorption, abortion, or mortality at or near parturition and had mated for a second time in the same season. Females 2 years and older were 95.4% parous, and 45.2% of the parous females 2 years of age and older had two sets of placental scars. The relatively high number of females with two sets of scars, indicates considerable production from second litters, but, at least in northern areas, the chances of these late-born young surviving their first winter are not good. We cannot determine from these data if the loss of implanted embryos is the same in adults as in yearlings. If both yearling and adult females lose the same percentage of their first and second matings as yearlings did of the first, and if all yearlings that lost their first litters mate again (an unknown factor), it means that 66% of the yearling and 86% of the adult females produce young each year. Average litter size for yearling females was 3.6 and for older females, 3.3. In a follow-up study comparing raccoons in Illinois and Missouri, Fritzell et al. (In Press) reported that pregnancy rates in both adult and yearling females were significantly higher in Illinois than in Missouri, that when both states were combined, the mean litter size of yearlings (3.30) was significantly smaller than that of adults (3.60), and that annual variation in pregnancy rates of yearlings (especially in Missouri) is probably a major factor affecting raccoon population dynamics. Mean litter sizes were not significantly different between Missouri and Illinois or among the 3 years (1979-82) of the study.

Payne (1982) presents a review of assessing productivity in furbearers, including the raccoon. He cites Steuwer (1943a, b), Sanderson (1950), Wood (1955), Sanderson and Nalbandov (1973), and Fritzell (1978) as pertinent references on ovarian and uterine analysis for determining productivity in raccoons. Sanderson and Nalbandov (1973) discuss in detail such things as corpora lutea, embryo counts, placental scars, and pseudopregnancy in the raccoon.

MANAGEMENT

Control

A common request to natural resource agencies for advice or assistance in removing unwanted raccoons from attics, walls, and chimneys of homes and for population reduction on waterfowl refuges and similar areas. During warm weather, when raccoons are active at night, it is sometimes possible to wait until after dark when raccoons have left attics and chimneys to feed and then prevent their re-entrance. Chimneys may be capped with securely fastened wire of heavy mesh. Once a raccoon is using a chimney, screen wire placed over the chimney, and secured with a wire wrapped around the screen and twisted to tighten the wire, is no deterrent to re-entry by a raccoon. It is usually relatively easy to determine entrance sites to the walls or attic of a home. These sites can be closed with good carpenter work. During winter, raccoons may not leave such sites each night, and it may be difficult to determine if they are present. In such situations it is a good idea to livetrap the animals before closing their entrance sites. If an adult raccoon is closed in a building, it will usually make an exit. Also, after the presumed offending animal(s) has been removed, it is a good idea to continue livetrapping for a week or two before closing the entrances. In winter, it may be necessary to keep the

livetrap set for several days before the animals feed. If there is easy access to the attic, I prefer to set the livetrap in the attic. Raccoons are usually active in attics, even in winter. However, the livetrap should be set on a piece of plywood or a large piece of flat metal so that the trapped raccoon cannot reach through the wire of the trap and disturb the insulation, electric wires, ceiling tiles, and anything else it can reach. During spring and early summer, raccoons in homes and chimneys are often females with young. The female may go out to feed and leave the young behind. In such situations, care should be taken not to remove the female and close the young in the building. Livetraps and bait are discussed under LIVETRAPPING AND TRANSPORTING.

"Trapping is the most satisfactory method of controlling raccoons. Hunting is restricted to established seasons and seldom removes enough offending animals to stop damage (Anon 1959)." Atkeson and Hulse (1953) reported on the relative numbers of raccoons removed from the Wheeler National Wildlife Refuge in northern Alabama by night hunting and by steel trapping. In the seasons of 1949, 1950, and 1951, 1,677 raccoons were removed by hunters and 359 by trappers. Thus, it may be more "efficient" to have hunters remove raccoons from an area than to have trappers remove them in terms of numbers removed; however, in terms of man hours spent per raccoon removed, it is more efficient to remove raccoons by steel trapping. Twichell and Dill (1949) removed 102 raccoons from 100 acres in Missouri with a crew climbing trees and pulling raccoons from dens during daylight hours.

Stocking

Woehler (1957) reported that Wisconsin was still stocking raccoons even though the wild population was so high in some areas that raccoons

were serious predators on waterfowl nests. Stuewer (1941a) concluded that stocking of raccoons in Michigan would be prohibitively expensive, would not materially increase the take of raccoons, that the release of a few pen-raised raccoons would have little or no effect on the population, and that restocking was not essential for the recovery of raccoon populations in depleted areas. Even though some raccoon clubs are still buying raccoons from other states and releasing them as well as capturing raccoons in towns and cities and releasing them on their favorite hunting areas, it is safe to say that at present raccoon stocking is not necessary anywhere in North America.

Artificial Dens

Stuewer (1948) believed that the preservation of existing dens and the provision for a continued supply of dens by some means was essential for maintaining raccoon populations. Some 40 years of experience might cause some changes in his earlier beliefs; however, there is little doubt that some of the highest reported population levels of raccoons have been associated with a good supply of dens--but not always dens in trees. Stuewer (1948) reported good use of artificial dens. The highest use was of boxes 14" x 12" inside diameter with 38" from the entrance to the bottom of the box. His next boxes were not used extensively until they had been in place for some time. The species and diameter of the tree and direction of the nest entrance were not important. He also had evidence that small woodlots were used as community denning sites (in Michigan) for raccoons that carried on most of their activities on surrounding areas. Thus, he suggested placing artificial dens in small woodlots.

We know that raccoons make wide use of ground dens, brush and rubbish piles, homes, barns, corn cribs, hay lofts, machinery, chimneys, crevices

in rocks, and a host of other sites for both winter and summer denning, including sites for giving birth to young. Thus, in most cases, it is not necessary to provide artificial dens specifically for raccoons to have a substantial population of these animals.

Habitat

Factors that Preble (1941) believed to be responsible for the reduction in raccoon populations in Ohio were a 50% reduction in mileage of permanent streams in the past 75 years; a reduction in acreage of swamps and bogs; reductions in forests; the destruction of dens, including the cutting of den trees; increased hunting pressure; and running dogs in summer. Stuewer (1941b) recommended reducing the destruction of dens to a minimum, providing sanctuaries to furnish stock for depleted areas within 25 miles, no training of dogs before mid-September, and holding the cutting of nut-bearing trees (especially oaks) to a minimum. He (Stuewer 1943) also said that water was extremely important, but that there is little that can be done about the lack of a suitable water supply. He further recommended leaving at least one, and preferably two, dens per 15-20 acres and within 0.25 mile of a permanent water supply.

In the black prairie farmland of the central states, Yeager (1943) pointed out that drainage ditches were an important physical feature, and that these drainage ditches were important for furbearers, including raccoons. He showed that ungrazed ditch banks were more valuable for furbearers, including raccoons, than banks that were grazed. Wilson (1955) discussed recommendations for improving woodland acreage for raccoons in North Carolina: cut no hollow trees during logging; if den trees are lacking, install artificial dens; manage woodlands for oaks, persimmon, and

grapes--including planting fencerows and field borders with persimmon and grapes--and keep hogs out of the woods.

Amundson (1971) states, "Controlled harvesting of coon populations is the most important single management measure.... But they are tenacious of life, and the diversity of their diet makes it relatively easy for them to bear up well under heavy hunting and trapping pressure." Although hunting and trapping are probably the most important mortality factors for raccoons throughout much of their range, I believe that the effects of hunting and trapping regulations on raccoon populations are generally overestimated. However, I hasten to add that prolonged high harvests when pelt prices are extremely high, as they were during the 1978-79 and 1979-80 seasons (Sanderson 1984), if maintained for long periods, might eventually have a depressing effect on the population. Sanderson (1951a) reported that Missouri instituted a season bag limit of 10 raccoons and shortened the open season from 46 to 31 days for the 1940 season. The harvest declined from nearly 30,000 in 1939 to about 10,000 in 1940 but then increased to 30,000 again by 1943-44 when the length of the season was increased to 46 days. The harvest continued to increase at a steep rate, making it appear that the reduced harvest in 1940, 1941, and 1942 were responsible. However, Sanderson (1951b) presented harvest data for Iowa, where the hunting and trapping seasons remained unchanged from 1930-31 through the 1949-50 seasons and there were no bag limits. Yet Sanderson (1951b:529) concluded, "This population curve (for Iowa) is strikingly similar to the Missouri raccoon population curve since 1940...."

There was a considerable amount of pressure in Illinois to restrict the hunting and trapping seasons on raccoons when the reported harvest (68,174) in 1971-72, with an average pelt value of $2.95, increased to

310,593 in 1975-76, when the average pelt value was $14.00 (Sanderson 1984). However, my data collected at the same furhouse for the past 29 years indicated little or no change in the population, and in spite of high harvests, the numbers taken by hunters and trappers increased to a peak of 381,006 in 1979-80 (average pelt value $25.50) and remained above or near 300,000 each year through the 1982-83 season. By 1983-84, the reported harvest was 203,633 and the average pelt value was $13.15. I believe that the extremely cold weather that came about the middle of December 1983 and remained during the hunting (hunting season closed 13 January in the Northern Zone) and trapping seasons was a more important factor in the decline of the harvest in 1983-84 than was the decline in pelt value. In Illinois, from 1972-73 through 1983-84, hunters accounted for 77.01% of 4,902 raccoons examined, trappers for 21.64%, and automobiles for 1.35%.

From 1971-72 through 1983-84, the hunting season in Illinois has been 44 days except for 1979-80, when it was shortened to 29 days. Except for 1979-80, the trapping season in the Northern Zone opened 15 November and closed 29 December; in 1979-80 the dates were 10 November and 9 December. In the Southern Zone the opening date was 25 November and the closing date was 8 January except for 1979-80, when the dates were 20 November and 19 December. From 1977-78 through 1983-84 the hunting season in the Northern Zone was 65 days (15 November -19 January) in 1977-78 and 1978-79, 39 days (10 November -19 December) in 1979-80, and 59 days (15 November -13 January) from 1980-81 through 1983-84. In the Southern Zone the hunting season was 62 days (25 November -26 January) in 1977-78 and 1978-79, 39 days (20 November -29 December) in 1979-80, and 59 days (25 November -23 January) from 1980-81 through 1983-84. With the shorter season in 1979-80, the harvest (381,006) was the highest reported in Illinois for raccoons.

With a somewhat longer season in 1980-81, the harvest had declined to 314,777.

LIVE TRAPPING AND TRANSPORTING

Live Trapping

Butterfield (1954) described a modified box trap baited with sardines that he said produced the best results. He found that 40 traps on an area of 800 to 2,400 acres, depending on the density of the trapping, were enough to cover in 1 day. I prefer a trap that I modified slightly from the one described by Silver and Jarvis (1930). This trap is 12" high, 12" wide, and 30" long (see Sanderson 1982:9 for a drawing of the trap). The top, bottom, and back are wood and the sides are covered with 1-inch mesh, 14 gauge wire. Details of the trap are given in the specifications for the trap.

I carry extra staples for fastening the treadle to the wire that holds it, an extra piece of #9 wire, one or two pieces of scrap lumber for the treadle, a pair of heavy pliers, and a hammer when livetrapping raccoons. Some raccoons do little or no damage to the inside of the trap, but others will chew the wooden treadle to shreds and bend the trigger wire and the wire that holds the treadle, although seldom is any permanent damage done to anything other than the treadle.

Dry, chunk-style dog food makes an excellent bait. If insects and mice consume large quantities of bait, take a small, glass jar (a baby food jar is good), cut a circle out of the metal lid, place the bait in the jar, place a screen wire cover over the top of the jar, and replace the screw-top cover. This makes an effective bait for raccoons and protects the bait from insects and small mammals. Fresh or canned fish makes an excellent bait, and when placed at the back of the trap on the wooden

bottom, the fluid from the decaying fish will soon "bait the trap permanently" for raccoons. A trap of this size baited with dry dog food will catch, in addition to raccoons, opossums, squirrels, cottontails, skunks, ground squirrels, woodchucks, an occasional gray fox, domestic cats, dogs, and a few birds. Mice, weasels, and flying squirrels apparently escape through the 1-inch mesh.

These traps may be set in wooded areas and other suitable locations out of doors for trapping raccoons. They also work well when set in attics, on a flat roof, and in yards and gardens to capture unwanted raccoons in urban areas. When the trap is set inside a building or on a roof, make sure that the raccoon cannot reach shingles, insulation, wires, etc., through the wire sides of the trap. If it can, set the trap on a piece of plywood or flat metal to protect the surroundings. The dimensions of this trap can be expanded or reduced to trap animals of other sizes. A larger version of this trap makes an excellent livetrap for large feral dogs.

Adult males often chew the treadle to the point that it has to be replaced and may also bend the trigger and wire that fastens the treadle. These wires are straightened with a pair of heavy pliers, the replacement treadle fastened to its supporting wire with staples, the trigger wire refastened to the treadle with another staple, and the trap reset.

Handling Live Raccoons

I will describe my methods for handling live raccoons and how these techniques are used to remove raccoons from live traps, to weigh, ear tag, and examine them before they are released. My "raccoon catcher," which I prefer to a noose with a steel cable such as is used for restraining swine, is made as follows. Take a manure fork handle, straighten the metal cover

into which the tang of the metal fork is inserted, bend a 3/8-inch steel rod in a 15-inch circle, weld a flat piece of steel (1/4" thick x 1" wide x 3-4" long) to the completed circle, insert this tang into the fork handle, and spot weld it to the metal covering on the end of the fork handle. Take a regular sized gunny sack, lap the open end over the steel circle, and sew the sack with heavy cord to fasten it to the circle. The string should not cross the steel rod. If it does, abrasion will cut through the string. Such a "catcher" is good for several months of intensive use before the gunny sack will need to be replaced. This catcher is convenient for catching live raccoons in the air as they are pulled from or jump from trees and for capturing running raccoons on the ground. It is also used to catch captive raccoons in their cages or raccoons in buildings. Once the raccoon is in the sack, it runs immediately to the rear of the sack. When it hits the rear of the sack, quickly twist the sack over once and lay the metal circle flat on the ground or floor. This action will hold the raccoon, if a foot is placed on the handle, until you are ready for the next step with the raccoon. If the sack is not twisted, when the raccoon hits the bottom of the sack, it will quickly turn around and climb out.

Once in the sack, the raccoon may be transferred directly to a carrying cage or a cage for holding it in captivity. If the raccoon is to be examined or marked, I take my wire "cone" (described below) in my right hand, the handle of the catcher in my left hand and lift the raccoon off the ground or floor. The raccoon's weight will cause the sack to straighten and the top to be open fully. As soon as the sack is open, I force the wire cone over the raccoon's head and the raccoon well up into the cone. As soon as the raccoon is in the cone, I immediately release the raccoon catcher with the left hand and place the left hand behind the

raccoon to prevent it from backing out of the cone. Do not let it back far enough out so that it can turn around in the cone. Raccoons are adept at this maneuver, and you do not want to be dealing with the anterior end of an angry raccoon with your bare left hand. I take three or four sticks about 0.5-inch in diameter and 20 inches long with a small fork on one end (osage orange is excellent) and force them through two sides of the wire cone and tightly behind the raccoon. They should keep the raccoon's nose snugly against the bottom of the cone. In this position, the raccoon cannot escape and cannot bite (unless you get careless and put a finger inside the cone) or scratch. You can examine the raccoon, collect external parasites, determine the sex, determine the body weight directly if the tare weight of the cone and sticks are known, tag the ears, anesthetize the animal, carry it a considerable distance to be placed in a carrying cage, placed in captivity, or released. If the raccoon is to be released, turn the cone away from you, remove the restraining sticks, and allow the raccoon to escape. The released raccoon will always run away from you. With these two pieces of equipment, one person can handle any wild raccoon, including removing it from a livetrap, and examining, weighing, and marking it.

To remove a raccoon from a livetrap, I use only the wire cone and do not carry the catcher when livetrapping raccoons. When a raccoon is in a livetrap, get out the materials you will be using--such as scales, and ear tags--and place them where you can reach them easily. Take the cone in your right hand; set the trap on end with the left hand (in this position the door lock, which hangs in the proper place by gravity, may release and the raccoon may raise the door; so watch that this does not happen); pull the sliding door out of the trap with your left hand and drop it; and

immediately insert the wire cone into the trap, forcing it over the nose of the raccoon and forcing the raccoon well into the cone. Quickly insert your left hand into the trap and place it behind the raccoon to hold it firmly in the wire cone. Again, do not allow the raccoon to back out enough to turn around inside the cone. Lift the cone out of the livetrap while holding the raccoon in the cone with the left hand and lifting with both hands. Immediately set the closed end of the cone on the ground and insert the sticks behind the raccoon to hold it in the cone as has been described. Proceed as described earlier to handle the raccoon.

The wire cone is made of the same 1-inch mesh, 14-gauge animal wire that is used on the traps. Wire of higher gauge (smaller wire) will not withstand the pressure that is sometimes necessary to force a raccoon into the cone. Because the wire is so stiff, cones are difficult to shape properly, but once made are practically indestructible. For general handling of raccoons, I use cones of two sizes. If you expect to handle a large number of raccoons weighing 2-4 pounds, a third size (smaller) is convenient but not essential. A cone to be used with livetrapping must be small enough at the base to go readily into the livetrap. It should be about 10 inches in diameter at the open end, 3.5 inches in diameter at the closed end, and 30 inches long. If you expect to handle several very large raccoons that were not livetrapped, a slightly larger cone would be convenient. A second size should be about 8-9 inches in diameter at the open end, 3 inches in diameter at the closed end, and about 20 inches long. As the cone is shaped during construction, lap some of the wires at the closed end (a hammer may be necessary to help shape the cone) so that the raccoon's nose (and teeth) cannot protrude. Closing the end of the cone

will protect the raccoon's nose from injury and your hands and fingers from the raccoon.

Carrying Cages

Convenient carrying cages can be made quickly and easily with the same 1-inch mesh, 14-gauge wire used for the livetraps and cones. The size can vary according to your needs, but a carrying cage 12" high x 20" wide x 30" long is convenient for one large adult, two smaller animals, or a female and her litter. Cut the wire to size and make sure that no sharp ends project. Fasten the top, bottom, and back together with shoat rings placed about every 2 inches. Cut a wooden frame of about 1.5-inch square stock and fasten it inside the open end with staples. Make a door frame of similar stock and cover it with a piece of the same wire used for the cage. Hang the door with two small, but sturdy, hinges. Put two fasteners (either hooks and eyes or small, sturdy hasps with snaps to secure them) on the door. These are used to secure the door quickly when a raccoon is put in the cage, but they must not be depended on to secure the door for extended periods. I use soft wire at the top and bottom of the door, both pieces well twisted, to secure the door for any extended period. Use heavy wire (I usually use scrap pieces of electrical wire covered with insulation) to make a convenient carrying handle. Make the handle long enough so that a raccoon cannot reach through the wire and scratch your hand while you are carrying the cage. If you are transporting large numbers of raccoons or sending them for some distance, wooden shipping crates should be used.

Wire cones may be used, without an intermediate step with the raccoon catcher, to remove raccoons from large cages or from buildings. If captive raccoons are handled several times, they become adept at dodging the cone

and using their hands to push it to one side as you try to get them into it. In these cases, I use the catcher first and then the cone.

You can make your own innovations and develop your own preferred techniques for handling raccoons. The simple equipment described here is simple to make, inexpensive, sturdy, and enables one person to handle the largest raccoon you will encounter. However, one word of caution. Raccoons are intelligent and very strong and can practically turn around inside their own skin. If you get careless while handling live raccoons, you will live to regret it.

Specifications for Raccoon Livetrap

1. Outside dimensions. 12"x12"x30".
2. All lumber except treadle to be rough white cedar, cypress, redwood, or pressure treated lumber.
3. Bottom, of wood. 1 piece 3/4"x11-3/4"x29-1/4".
4. Top, of wood. 1 piece 3/4"x11-3/4"x27-7/8".
5. Back, of wood. 1 piece 3/4"x11-3/4"x12".
6. Treadle, of wood. 1 piece 3/4"x5"x10" (may be fir, white pine or other suitable wood); 1 piece #9 wire 13" (stapled to treadle and inserted through holes drilled about 3/4" above bottom of trap in upright treadle supports).
7. Front uprights, wood. 2 pieces 2"x2"x21". Inside of each to have a groove 1/4" wide and 5/8" deep to hold steel drop-door.
8. Upright treadle supports, wood. 2 pieces 3/4"x2"x12".
9. A trigger of #9 wire to run from the treadle through an eye screw in top piece. Approximately 3' of wire needed per trap.
10. Drop door of 18 gauge sheet steel, 10-1/4"x12"; lighter gauge steel must not be substituted for this door.

11. Triangle door lock to be of 18 gauge sheet metal. Lighter gauge steel must not be substituted. This is a simple triangle cut out of the sheet steel.
12. The part of the front wooden uprights which are exposed to the inside of the trap when the door is down are to be covered with 26-gauge sheet steel to prevent raccoons from chewing the wood. Each of these pieces will be approximately 12"x2-1/2", bent lengthwise at a 90° angle.
13. Sides of welded wire, 30" wide, 1"x1" mesh, 14-gauge bethanized welded wire (sometimes called "animal wire"). This wire must be 14 gauge 1"x1" mesh and must be galvanized after welding. Other wire, although cheaper, is not satisfactory.

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FIGURE LEGENDS

Fig. 1. Seasonal variations in the average weight of one testis in adult and juvenile raccoons. With each mean are the number of observations and a vertical line representing the mean plus or minus one standard error. All animals were taken in Illinois from November 1955 through April 1961 (From Sanderson and Nalbandov 1973).

Fig. 2. Seasonal variations in the average total weight of both ovaries from parous or pregnant and nulliparous raccoons. With each mean are the number of observations and a vertical line representing the mean plus or minus one standard error. All animals were taken in Illinois from July 18, 1958 through May 30, 1961 (From Sanderson and Nalbandov 1973).

Fig. 3. Sizes of uterine swellings in raccoons at various numbers of days prepartum. The line was fitted by least squares, not including Llewellyn's data. The dash line, an extension of the line to conception 63 days prepartum, is not based on data. The size used for the uterine swelling at conception was 5 mm, the approximate average diameter of the uterus during estrus (From Sanderson and Nalbandov 1973).

Fig. 4. Raccoon uterus split to show two groups of placental scars. This female was killed on January 23. Two light scars were only barely visible in the photograph but were readily visible in the fresh specimen. Their locations and densities relative to the three dark scars are indicated by the light stippling (arrows) (From Sanderson and Nalbandov 1973).

Fig. 5. Schematic drawing (side view) of the reproductive system of an adult male raccoon (From Sanderson and Nalbandov 1973).

Fig. 6. Schematic drawing (ventral view) of the reproductive tract of a parous female raccoon (From Sanderson and Nalbandov 1973).

Fig 1

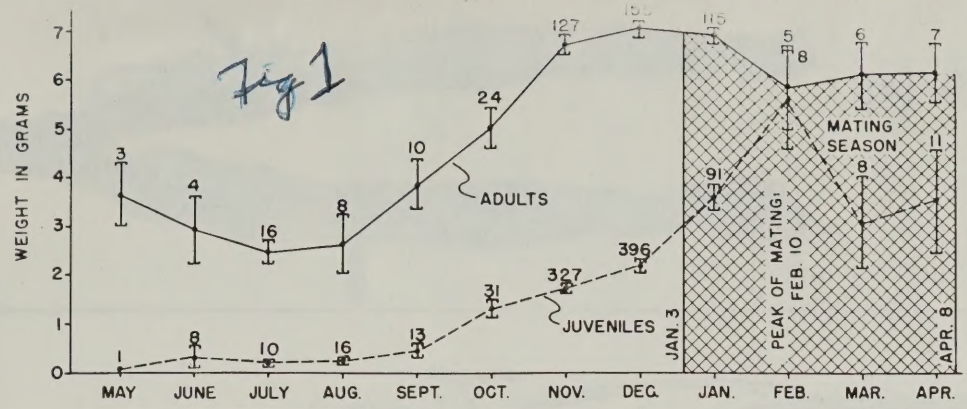


Fig 2

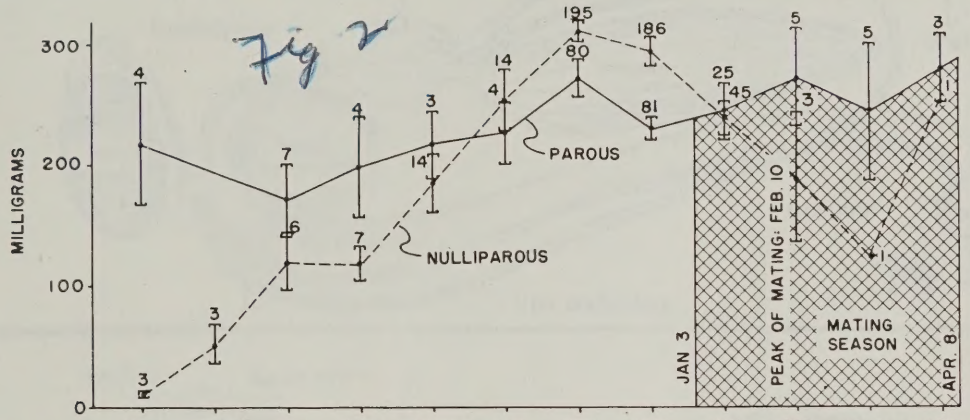
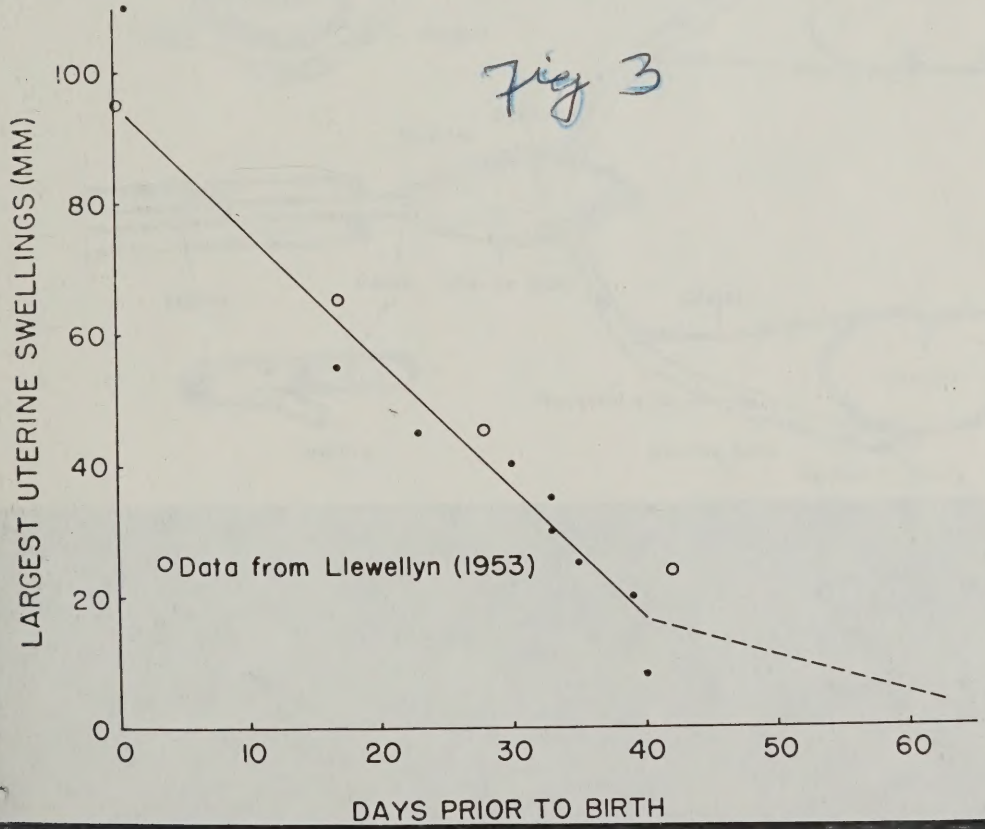
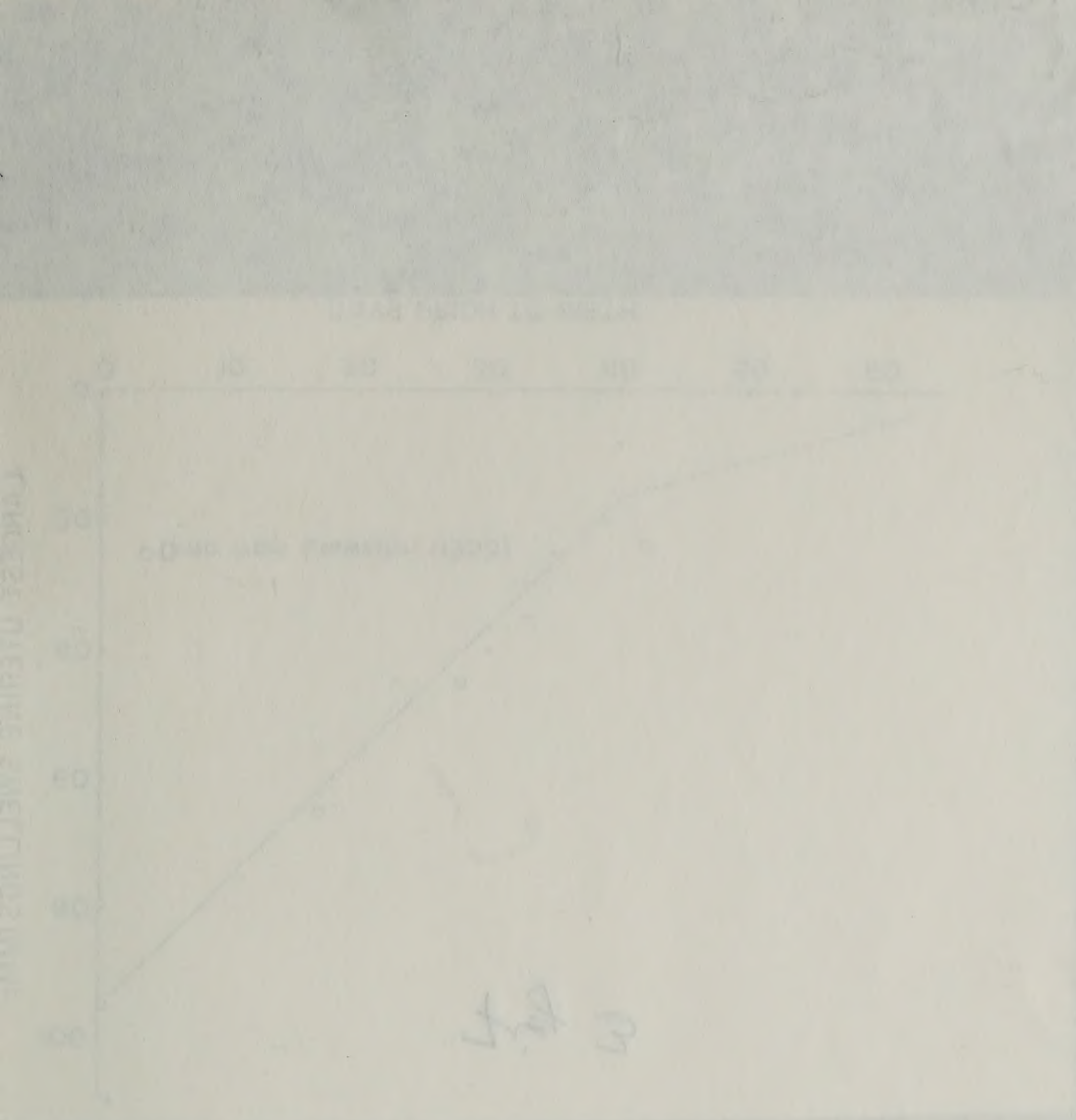
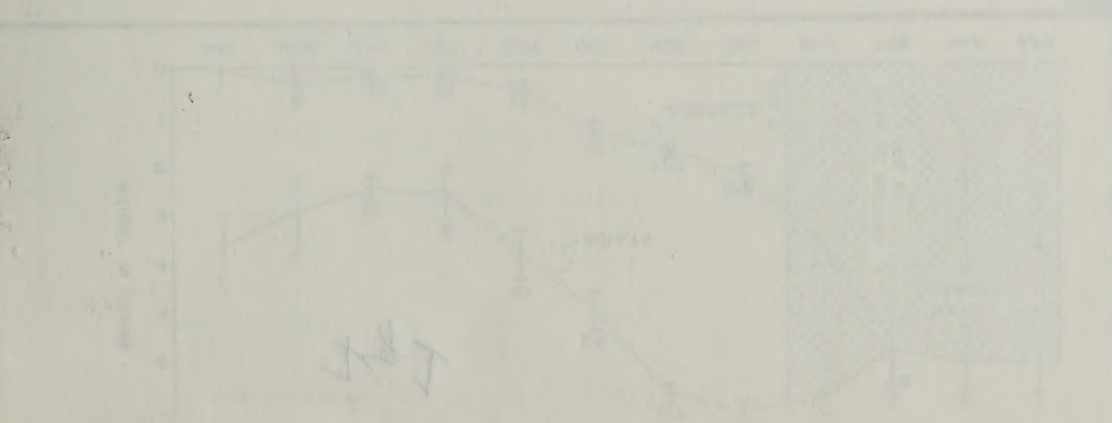


Fig 3







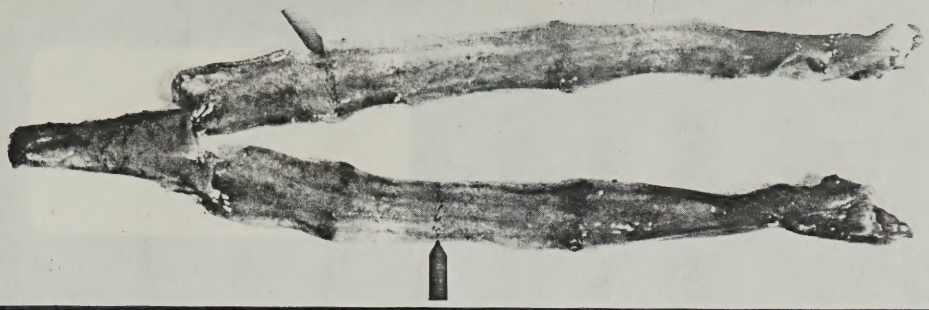


Fig 4

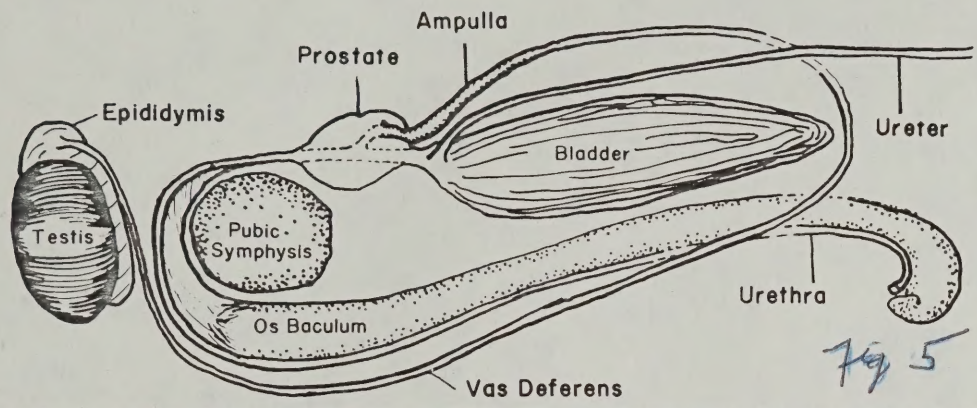


Fig 5

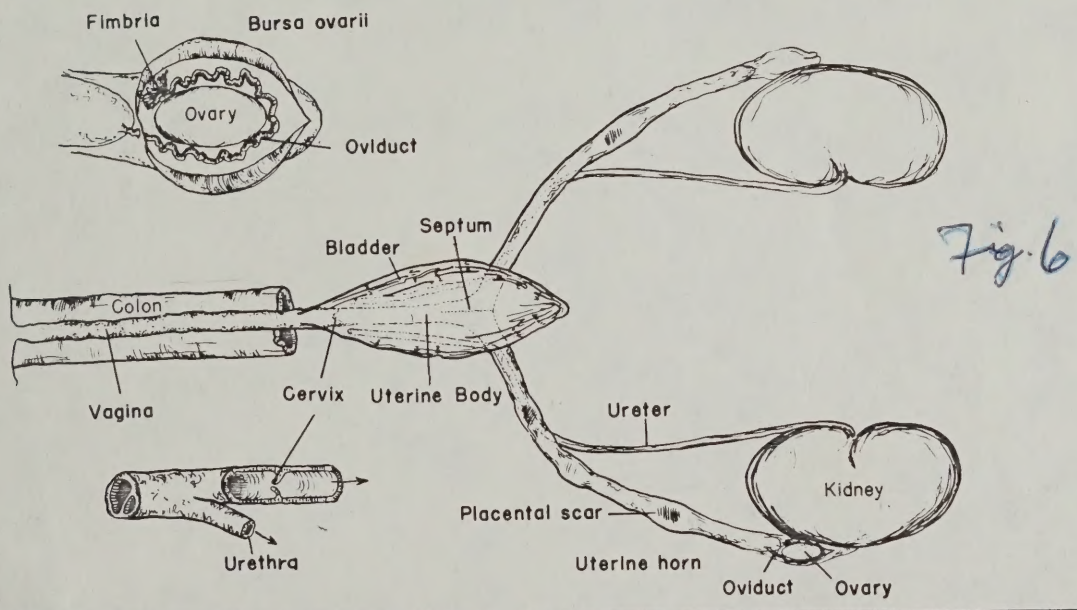


Fig. 6